



CONTITU	CLASSIFICATION OF TH	IS PAGE						
			REPORT DOCUMENTATION PAGE					
			1b. RESTRICTIVE MARKINGS					
A	D-A147	423						
				3. DISTRIBUTION/A				
20. DECLA	SSIFICATION/DOWNGR	ADING SCHE	DULE		for public			
				Distribution unlimited.				
	MING ORGANIZATION	REPORT NUN	ABER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)				
A	AFGL-TR-84-0277				•			
64 NAME OF PERFORMING ORGANIZATION 86. OFFICE SYMBOL				7a. NAME OF MONITORING ORGANIZATION				
Air Force Geophysics Laboratory (If applicable) LYC								
Sc. ADDRESS (City, State and ZIP Code)				7b. ADDRESS (City, State and ZIP Code)				
Hanecom	n AFB, MA 01731			i				
110113001	. A.D, IM 01731	•		ŀ				
	OF FUNDING/SPONSOR	ING	St. OFFICE SYMBOL	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER				
	NIZATION rce Geophysics I	.ahorator	(If applicable) v LYC					
	SS (City, State and ZIP C		7	10. SOURCE OF FUNDING NOS.				
				PROGRAM	PROJECT	TASK	WORK UNIT	
Hanscon	n AFB, MA 01731			ELEMENT NO.	NO.	NO.	NO.	
11. TITLE	(Include Security Classific	tion) Snow	Characterization	62101F	6670	667012	66701206	
Measure	ements from SNOW	I-TWO/Smol	Characterization ke Week VI					
	NAL AUTHOR(S)	TO RED	rupi					
BARBARA A. MAIN, ROBERT O. BERTHEL 13a TYPE OF REPORT 13b TIME COVERED				14. DATE OF REPOR	RT (Yr., Mo., Day	15. PAGE	COUNT	
	EPRINT	FROM	то	1984 October 26 9				
16. SUPPLE	EMENTARY NOTATION		ed at SNOW/TWO/S	moke Week VI	Symposium	14-16 Aug 19	984,	
		CRREL,	Manover, NH.					
17.	COSATI CODES		18. SUBJECT TERMS (C				17)	
FIELD	GROUP SL	. GR.	FALL VELOCITY					
			SNOW RATE CRYSTAL STRUC	SNOW/ONE/A CTURE SNOW/ONE/B				
19. ASSTR	ACT (Continue on reverse	if necessary an	d identify by block number					
U Snow	characterisatio	n mes eure	ments acquired d	ingtoe CMAU_TU	M/Smoke We	ek Were o	Tagantad	
A sum	mary of data for	r 8 days	in January 1984	is given. Th	ese data c	onsist of f	all velo-	
city,	snow structure	, and sno	wrate as recorde	d by Laborato	ry prototy	pe equipmen	t. A new	
			the fall velocity velocity					
select	ted periods. k	LD, IEII	verocity and cry	scar type inr	ormation #	re presente	d TOP	
	1							
	- 1					\mathbf{C}	CTE	
	1					EL	7 984	
						10 M	ECTE N 1 3 1994	
20. DISTRI	SUTION/AVAILABILITY	OF ASSTRA	CT	21. ABSTRACT SECU	JRITY CLASSIFI	CATION	-	
UNCLASSIFIED/UNLIMITED 🗗 SAME AS RPT. 🗆 DTIC USERS 🗆				UNCLASSIFIED				
	OF RESPONSIBLE INDI			22b. TELEPHONE N	UMBER	23c. OFFICE SY	MOL	
	SARA A. MAIN	- -		(617) 861-29		LÝC		
				/// 001-27	~·	1 2.0		

C FILE COF

DD FORM 1473, 83 APR

EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED

AFG L-TR-84-0277

SNOW CHARACTERIZATION MEASUREMENTS FROM SNOW-TWO/SHOKE-LEEK VI

Berbera A. Main Robert O. Berthel

Cloud Physics Branch (LYC) Atmospheric Sciences Division Air Porce Geophysics Laboratory Hanscom AFB, MA 01731

ABSTRACT

Snow characterization measurements acquired during SNOV-TWD/Smoke Week VI are presented. A summary of data for eight days in January 1984 is given. These data consist of fall velocity, anow structure, and snow rate as recorded by laboratory prototype equipment. A new concept of back lighting on the fall velocity indicator is discussed and data examples shown. Snow rate plots, fall velocity and crystal type information are presented for selected periods.

1. Introduction

Air Force Goophysics Laboratory (AFGL) measurements recording the characteristics of naturally falling snow were made at Camp Grayling, MI during January 1984, in support of SHOW-TWD/Smoke Work VI. Other related experiments were held proviously in the wint- 1981-1982 at Camp Ethan Allen, Joricho, VI in support of SHOW-GHZ-A, and at Camp Grayling, MI during Bosenber 1982, in support of SHOW-GHZ-B. The sponsoring organisation for those three experiments was the W.S. Army Cold Regions Bosenth and Engineering Laboratory

(WI) to measure fall velocity, the snow structure recorder (SSR) for crystal identification, and the snow rate meter (SRM) to measure snowfall rate. These instruments are described and operational methods employed are discussed in previous reports, SNOW-ONE-A, Data Report (Berthel, 1982); SNOW-ONE-B, Data Report (Berthel, et.al., 1983); at Smov . Symposium II (Berthel, et.al., 1982); SPIE Symposium (Plank, et. al., 1983); in an ARGL Report (Gibbons, et. al., 1983); and at Snow Symposium III (Berthel, et. al., 1983). This paper is concerned primarily with the presentation of data recorded by the three AFGL prototype instruments and analysed for future comparisons with results of other test participants. Instrument modifications are presented.

2. Instruments

The fall velocity indicator (WI) and the snow structure recorder (SSR) were modified for use at \$8000-TMO/Smoke back VI.

One problem with the FVI has persisted since instrument conception, that of weak or faded video images. In the front lighting configuration used for SNOW-ONE-A and SNOW-ONE-B, strobed light was reflected from the particle into the camera. The amount of reflected light varied with crystal size, shape, structure, and spatial configuration. This variation combined with limited video resolution and image magnification made it difficult for the analyst to identify salient features on which to base measurements. This problem was compounded when a particle tumbled or oscillated as it fell, and resulted in a broad scattering of fall velocity determinations.

To enhance particle definition, it was decided to modify the TVI to a back lighting concept. A strobe lamp was asunted at the rear of the sample chamber behind a ground-glass screen such that the diffused light would enter the enters directly. This configuration provides a shedow image of the falling particle with better contrast and definition. Further, this method has permitted

SNOW CHARACTERIZATION MEASUREMENTS FROM SNOW-TWO/SMOKE-WERK VI

Berbera A. Main Robert O. Berthel

Cloud Physics Branch (LYC) Atmospheric Sciences Division Air Force Geophysics Laboratory Hanscom AFS, MA 01731

ABSTRACT

Snow characterization measurements acquired during SNOW-THO/Smoke Week VI are presented. A summary of data for eight days in January 1984 is given. These data consist of fall velocity, snow structure, and snow rate as recorded by laboratory prototype equipment. A new concept of back lighting on the fall velocity indicator is discussed and data examples shown. Snow rate plots, fall velocity and crystal type information are presented for selected periods.

1. Introduction

Air Force Geophysics Laboratory (AFGL) measurements recording the characteristics of naturally falling snow were made at Camp Grayling, MI during January 1984, in support of SHOW-TWO/Smoke Work VI. Other related experiments were held previously in the winter 1981-1982 at Camp Ethan Allen, Jericho, VI in support of SHOW-OHE-A, and at Camp Grayling, MI during December 1982, in support of SHOW-OHE-B. The sponsering organisation for these three experiments was the U.S. Army Cold Regions Research and Engineering Laboratory (CREEL).

AFGL interests lay in three directions: fall velocity measurements, crystal identification, and snow rate measurements. The needed information was gathered by three AFGL prototype instruments: the fall velocity indicator

(SRM) to measure snowfall rate. These instruments are described and operational methods employed are discussed in previous reports, SNOW-ONE-A, Data Report (Berthel, 1982); SNOW-ONE-S. Data Report (Berthel, et.al., 1983); at Saov . Symposium II (Serthel, et.al., 1982); SPIE Symposium (Plank, et. al., 1983); in an ARGL Report (Gibbons, et. al., 1983); and at Snow Symposium III (Berthel, et. al., 1983). This paper is concerned primerily with the presentation of data recorded by the three AFGL prototype instruments and analysed for future comparisons with results of other test participants. Instrument modifications are presented.

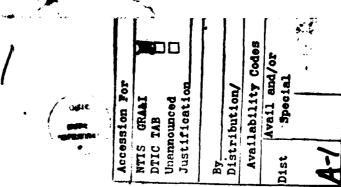
2. Instruments

The fall velocity indicator (WI) and the snow structure recorder (SSR) were modified for use at SNOW-TWO/Smoke Week VI.

One problem with the FVI has persisted since instrument conception, that of weak or faded video images. In the front lighting configuration used for SNOW-ONE-A and SNOW-ONE-B, strobed light was reflected from the particle into the camera. The amount of reflected light varied with crystal size, shape, structure, and spatial configuration. This variation combined with limited video resolution and image magnification made it difficult for the analyst to identify salient features on which to base measurements. This problem was compounded when a particle tumbled or oscillated as it fell, and resulted in a broad scattering of fall velocity determinations.

To enhance particle definition, it was decided to modify the FVI to a back lighting concept. A strobe land was mounted at the rear of the sample chamber behind a ground-glass screen such that the diffused light would enter the cenera directly. This configuration provides a shedow image of the falling particle with better contrast and definition. Further, this method has permitted a large reduction in the instrument's physical sise. The only drawback to this method is that a mirror used to determine the third dimension of particles ! is now useless. As the FVI was not designed with particle identification as a prime function, this limitation is ecceptable. Image comparison photos

1 - Supergrave Compression





Francisco Appella



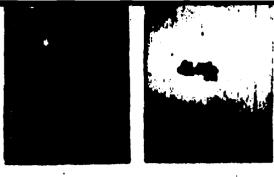
ALCOHOL:

Figure 1. Image comparison showing a reflected image on the left and a shadow image on the right.

from SHOW-ONE-B and SHOW TWO/Smoke Week VI are seen in Figure 1. The sharper image is evident. The FVI has been modified since January 84 to increase the volume of snow entering the instrument and further improvements in both definition and collection capabilities are being planned. Consideration is being given to digitizing the video for future operations.

The snow structure recorder (SSR) had some minor changes made prior to the January tests. To increase the number of particles available for analysis, the 'stop/go' mechanism was stepped down from 1 1/2" to 3/4" to decrease belt movement, thus doubling the amount of time of each sample.

1964	17/1	1: 96R	SRM	REMARKS
9 Jan (84-01)	1022-1535	HOHE	0015-0330(10th)	Occasional very light enew - mostly deadrites
12 Jen (84-03)	0724-0757	HOME	0705-0100(13th)	One period of light snow 1-2 mm stellers, same medica
13 Jan (84-04)	0045-1200	0845-1200	0855-0100(14th)	Sporedic light seaw - stel- lars, aggregates of stellars and dendrites to Jun.
16 Jen (84-05)	0750-23400	9739-2400	6747-6650(17th)	Periodo of light to molorate enov-escilco < lem, descritos etaliero, and eggregates to lem
17 Jan (84-86)	0001-1105	0001-110 5	0047;-0012(10ch)	Two jurisds of very light core dendrites (.len, aggregates of dendrites (len.
22 Jan (84-11) (84-12)	0050-0526 1569-1730	0000-0000 1500-1730	0003-4900 1901-6731	Pertode of Hight saw and Shutfles anothly stollars 3- 3m
23 Jan (94-13)	1409-0045	1465-0045	3422-0100(24th)	Periode of light and anderete sees- stellers, dendrites,



Pigure 1. Image comparison showing a reflected image on the left and a shadow image on the right.

Action 6

A section with the

ified since January 84 to increase the volume of snow entering the instrument and further improvements in both definition and collection capabilities are being planned. Consideration is being given to digitizing the video for future operations.

The snow structure recorder (SSR) had some minor changes made prior to the January tests. To increase the number of particles available for analysis, the 'stop/go' mechanism was stepped down from 1 1/2" to 3/4" to decrease belt movement, thus doubling the amount of time of each sample.

1964	WI	: 68E	SRM	REMARKS
9 Jan (84-01)	1022-1535	HOME	0815-0338(10th)	Occasional very light enew - mostly dendrites
12 Jen (84-03)	0724-0757	HOME	0705-0100(13th)	One period of light enew 1-2 m stellers, sees modeles
13 Jan (84-04)	0845-1200	0945-1200	0855-0100(14th)	Sporadic light enew - etcl- lars, aggregates of etcliars and dendrites to Jun.
16 Jan (84-05)	0758-23400	0730-2400	0747-0830(17th)	Periods of light to understa snow-modiles < lum, dendrites stellars, and aggregates to Sum
17 Jan (84-06)	0901-1105	00 01-1105	0847;-0812(18th)	Two periods of very light enew dendrites <.5cm, eggregates of dendrites < lum.
22 Jan (84-11) (84-12)	0056-0528 1529-1730	0058-0528 1529-1730	0053-0530 1551-1751	Periods of light enew and flurfice mostly stellars 2-
23 Jan (04–13)	1405-2045	1403-2045	1423-0400(24th)	Periode of light and molerate snow- stellars, dendritos, amorphous, snow pollets 2-3um
24 Jan (84-14)	1004-1206	1004-1208	6934-2354	Sporadic very light ener -

TABLE 1: DATA SURGIARY

Colony favour Street Colon to Indiana for the printing tyches it, themant t.

Prince to the market for the total three and prince markets for the title three.

2_

Since the sampling area is essentially a slot, collection efficiency is dependent upon instrument position with respect to wind direction. The instrument has been mounted on a manually rotated table that allows it to be faced into the wind. Current plans are to mechanize this table and considerations are being made to similarly configure the FVI. The differences in the numbers of particles seen on the SSR during the recent experiments are significantly greater when compared to the numbers seen of the FVI.

The snow rate meter was essentially the same as that used in SNOW-ONE-3. As no fault with the SDM has been defined at this time, we presume the current readings to be correct. There are still concerns regarding air flow around the instruments, particularly the SRM, and smoke tracking studies are being conducted.

3. SNOW TWO/Smoke Week VI Data

The availability of personnel and budget restrictions prevented our participation in the first half of the SNOW-TWO/Smoke Week IV field exercise. Our Winnebego arrived on site after the Christmes recess and the instruments were in operation from January 8th thru January 24th. Snowfall measurements were made on eight (8) separate days. Table 1 shows these periods of operation and indicates snow intensities and observed crystal types. Of these days only two, 16 and 23 January, had sufficient enew falling into all three instruments to warrant further enalyses. For the other six days, very light enewfall was recorded by the SSN with very little data obtained by the IVI and SER.

The periode of study for the 16th and 23rd were determined by the number of particles seen on the fall velocity indicator (FVI). Because of the time consuming later involved, the explication were limited to the first fifty free falling porticles of each half thus period of comparettively known extendil. In addition, cryotal type and fall characteristics were determined with as such coursesy as the Mainteriese of the

snow rate data for these times were obtained.

4. 16 January 1984

On the 16th of January 1984, five study periods were selected: 2000, 2030, 2100, 2200, and 2230. All APGL instruments were operating during these periods of relatively good snowfall. During these periods the first fifty free falling particles seen on the . FVI were measured for largest dimension and for fall velocity. These messurements are shown in Figure 2, fall velocity ve size plots, with 4 the largest physical disension. The solid lines in the figures are the least square regression lines and the dashed lines show plus or minus one standard devistion. The dots are individual particles. The size range on this day is broad with largest dimensions from .3 mm to 16.6 um and fall velocities from .3 $extbf{m}$ sec $^{-1}$ to .95 a sec-1. Snow types seen on the fall velocity indicator are many: stellars, spatial dendrites, aggregates of dendrites and graupellike ency in the first and fourth cases; dendrites added in the 2030 sample; rimed dendrites and snow pellets during the 2100 sample; and rimed plates during the 2230 samples. Particles less than .3 mm are not visible on the IVI because of the limited videe recolution. There appears to be some relationship between particle size and fall velocity. Similarities do exist between current analyses and those preferred on SHOH-CHE-A and SHOH-CHE-B data as reported in SHOW-CHE-A and B Characterisation Measurements and Data Analysis (Borthol, et al, 1983). The suov structuse recorder(SSR) deta ves sined for the same five periods and particle types determine. Much the came particle variety observed as of MT in mon on the SSR. Sudples of o attity particle are com to its and ability to cove the instrum o like the speak has at speeds in the same to give good reducts. See r the five time periods are shown in Piguse 4. The enew vote motor (SRIQ

into the wind. Current plans are to mechanize this table and considerations are being made to similarly configure the FVI. The differences in the numbers of particles seen on the SSR during the recent experiments are significantly greater when compared to the numbers seen of the FVI.

The snow rate meter was essentially the same as that used in SNOW-ONE-B. As no fault with the SRM has been defined at this time, we presume the current readings to be correct. There are still concerns regarding air flow around the instruments, perticularly the SRM, and smoke tracking studies are being conducted.

3. SNOW TWO/Smoke Week VI Data

The availability of personnel and budget restrictions prevented our participation in the first half of the SNOW-TWO/Smoke Week IV field exercise. Our Winnebago arrived on site after the Christmas recess and the instruments were in operation from January 8th thru January 24th. Snowfall measurements were made on eight (8) separate days. Table 1 shows these periods of operation and indicates snow intensities and observed crystal types. Of these days only two, 16 and 23 January, had sufficient snow falling into all three instruments to warrent further analyses. For the other six days, very light enowfall was recorded by the SRM with very little data obtained by the FVI

The periods of study for the 16th and 23rd were determined by the number of particles seen on the fall velocity indicator (FVI). Because of the time consuming labor involved, the studies were limited to the first fifty free falling particles of each half hour period of comparatively heavy snowfall. In addition, crystal type and fall characteristics were determined with as such accuracy as the limitations of the vides system allows. These messurements may not be fully representative of the natural encufall distribution because of the small sample volume and enalyst subjectivity. The saw structure recorder (SSR) was used to type perticles at corresponding times. Detailed ,

On the 16th of January 1984, five study periods were selected: 2000, 2030, 2100, 2200, and 2230. All AFGL instruments were operating during these periods of relatively good snowfall. During these periods the first fifty free falling particles seen on the . FVI were measured for largest dimension and for fall velocity. These measurements are shown in Figure 2, fall velocity ve size plots, with 4 the largest physical dimension. The solid lines in the figures are the least square regression lines and the dashed lines show plus or minus one standard deviation. The dots are individual particles. The size range on this day is broad with largest dimensions from .3 mm to 16.6 um and fall velocities from .3 m sec-1 to .95 m sec-1. Snow types seen on the fall velocity indicator are many: stellars, spatial dendrites, aggregates of dendrites and graupellike enow in the first and fourth cases; dendrites added in the 2030 sample; rised dendrites and snow pellets during the 2100 sample; and rimed plates during the 2230 samples. Particles less than .3 mm are not visible on the FVI because of the limited video resolution. There appears to be some relationship between particle size and fall velocity. Similarities do exist between current analyses and those preformed on SNOW-ONE-A and SNOW-ONE-B data as reported in SNOW-ONE-A and B Characterisation Measurements and Data Analysis (Berthel, at al, 1983). The snow structure recorder(SSR) data was examined for the same five periods and particle types determine. Much the same particle variety observed as the PVI is seen on the SSR. Samples of the study periods are seen in Figure 3. The ability to move the instrument to face into the storm has made a significent change in the amount of data recorded. The current configuration continues to give good results. Samples for the five time periods are shown in Figure 4. The ency rate meter (SRM) functioned well on the 16th, much date are available but the enswfall was light. This instrument operated from 0747:30 on the 16th to 0050 on the 17th. During that period only light enow and enow showers occurred. valent snow rates of <.1 mm hr -1 were

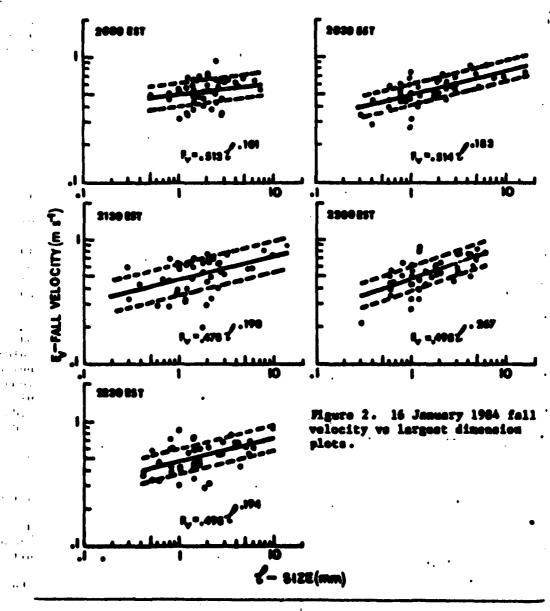
... 2

IVIANOS I. PREMONTE

trong to be authors, but now, and four numbers to the transfer to the first litera.

secol dereties thetamerica, sie sel.

ring to out their To be reduced for the printing

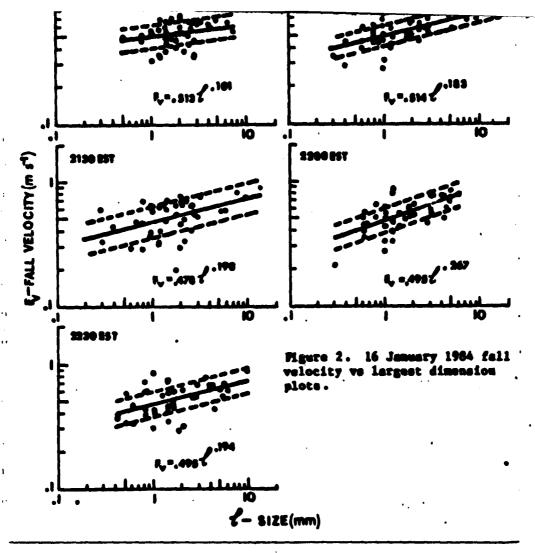


The product the setting of the Society of the Socie

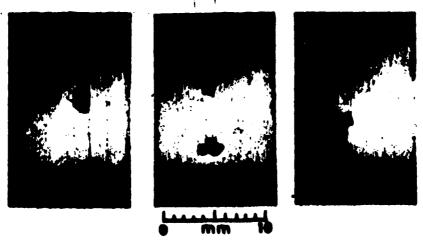
11,10 1 4000







the contract of the contract o



Tell relocity indicator perticle images on 16 January 1984.

the feet products the configuration

Pencil in outlier to be to come and proceedings to light " they

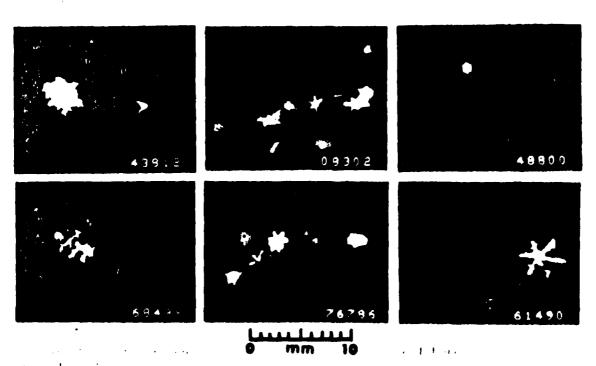
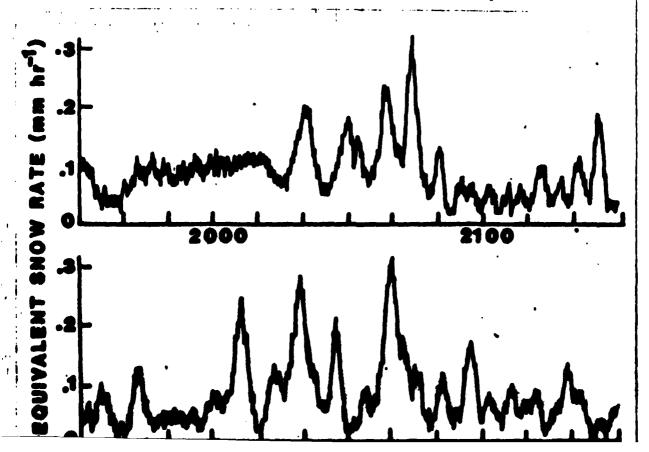
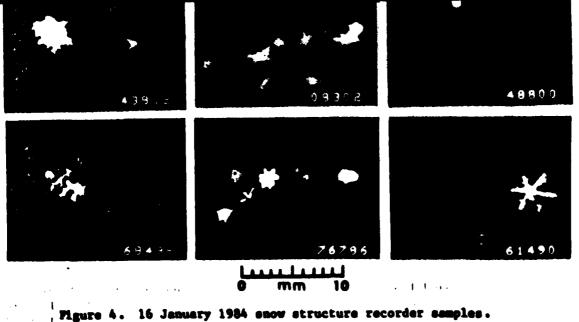


Figure 4. 16 January 1984 snow structure recorder samples.





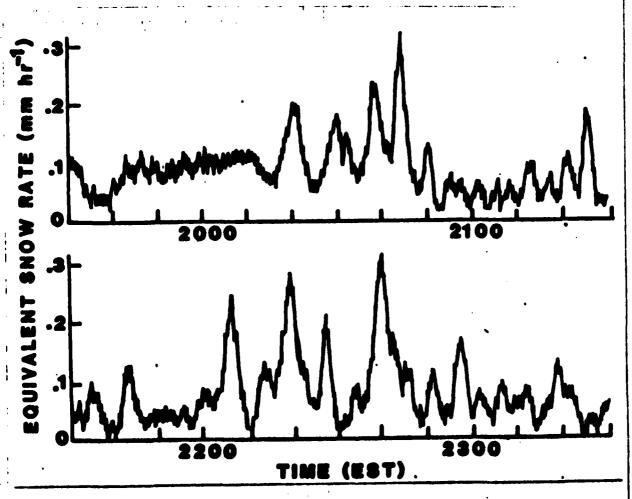


Figure 5. 16 Jenuary enew rate plots.

Anna garage of the high of their traand be refused 197 for printion)

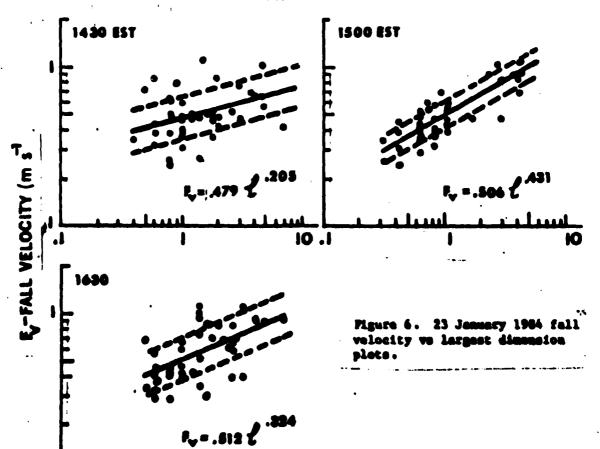
tenell in unther of the borner and page number to higher blood

recorded for much of the day with the heaviest period recording \sim .3 mm hr $^{-1}$ from 2000 - 2300. Figure 5 shows the snow rate plots.

5. 23 January 1984

The 23rd of January data was analysed in the same fashion as the 16th. While the snow was more intense than on the 16th, it was so only for short periods. Three periods of relatively good snow were selected: 1430, 1500 and 1630. The first fifty free falling particles were measured for fall velocity and maximum dimension. These measurements are shown in Figure 6 fall velocity we size plots with I the largest physical dimension. The solid line is the least squares regression line and the dashed lines show plus or minus one standard deviation. The dots are individual par-

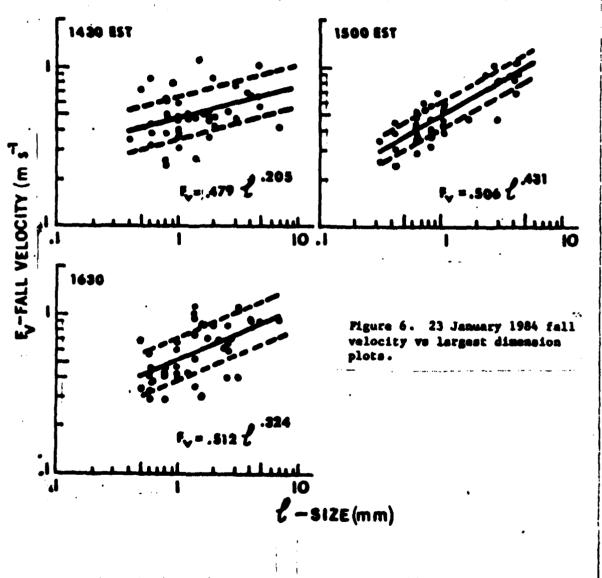
ticles. On this day the largest physical dimensions vary from .3 to 8.6 mm, considerably smaller than the 16.6 mm particles seen in the 16th Jan data. The fall velocities varied from .27 m sec-1 to 1.16 m sec-1, a broader range than seen on the 16th. Crystal types seen on the FVI were varied. The first study period included aggregates of stellars, capped columns, rimed plates, spatial dendrites, graupellike snow; the second, rimed dendrites, stellars, aggregates of plates, columns, and graupellike snow; the third, aggregates of dendrites, rimed dendrites, graupellike snow, plates, and columns. Samples from these periods are shown in Figure 7. The snow structure recorder shows a similar variety with bullet rosettes added in the 1430 period, and hexagonal graupel in the third. Samples are shown in Figure 8. The snow rate meter equivalency plots for these and surround-



5. 23 January 1984

The 23rd of January data was analysed in the same fashion as the 16th. While the snow was more intense than on the 16th, it was so only for short periods. Three periods of relatively good snow were selected: 1430, 1500 and 1630. The first fifty free falling particles were measured for fall velocity and maximum dimension. These measurements are shown in Figure 6 fall velocity was size plots with 6 the largest physical dimension. The solid line is the least squares regression line and the dashed lines show plus or minus one standard deviation. The dots are individual par-

The fell velocities veried from .27 m sec-1 to 1.16 m sec-1, a broader range than seen on the 16th. Crystal types seen on the FVI were varied. The first study period included aggregates of stellars, capped columns, rimed plates, spatial dendrites, graupellike snow; the second, rimed dendrites, stellars, aggregates of plates, columns, and graupellike enow; the third, aggregates of dendrites, rimed dendrites, graupellike snow, plates, and columns. Samples from these periods are shown in Figure 7. The snow structure recorder shows a similar variety with bullet rosettes added in the 1430 period, and hexagonal graupel in the third. Samples are shown in Figure 8. The snow rate meter equivalency plots for these and surround-.



Control of the control of the print of the control of the control

minist i banerel

.

Personal in matter of the transport and price numbers in transfer below.

According to engage

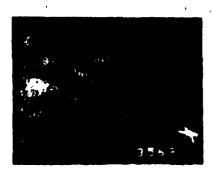
ing periods are seen in Figure 9. The hr⁻¹, while the three study periods show largest snow rate recorded was 2.2 mm maximum rates between 1.3 - 1.5 mm hr⁻¹. largest snow rate recorded was 2.2 mm Control of the Control



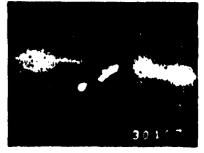




Pigure 7. Pall velocity indicator particle images on 23 January 1984.









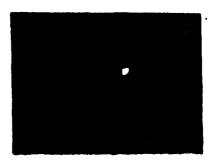


Figure 8. 23 January 1984 once structure recorder as





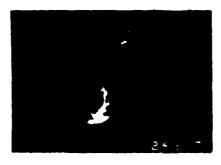
0 mm 10

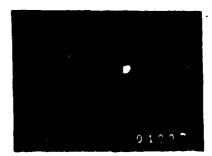
. Figure 7. Pall velocity indicator particle images on 23 January 1984.

3563









-0 mm 10

Pigure 8. 23 January 1984 enow etructure recorder samples.

. .

•

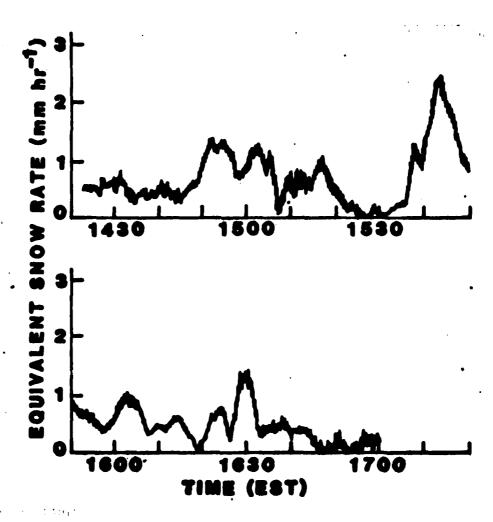
Comment of more than a second of the second

Millian I. Bildie 1.7

Court in authors' lost panels and page number to High blue.

2

the state of the s



Mgure 9. 23 January 1984 snow rate plots.

Conclusions

We have compared the fall velocity relationships from \$8000-780/Smoke Mock IV with those of \$8000-000-A and B (Berthel et al, 1963). The equations derived from the 23 January 1904 data generally match those from \$8000-000-B.

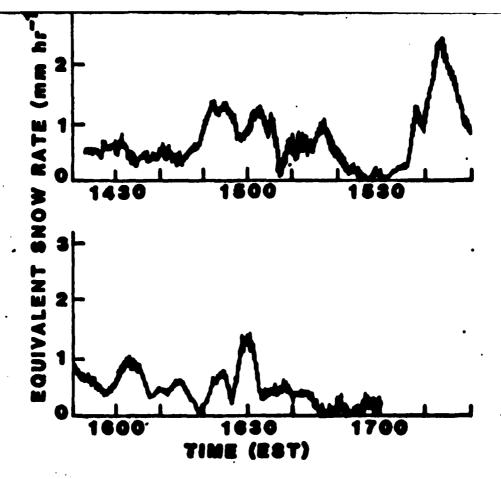
The equation, possible conform with those obtained on 16 January 1904, although the slopes from the 16th's data are generally smaller. The most obvious difference is seen in the coefficients from \$8000-000-A's 31 January 1962 store. These coefficients were

approximately forty percent higher.

The data gathered thus far in the SHOW projects are the beginning of a data base. We feel that the refinements made in both instrument performance and data reduction techniques will enable us to expend this base greatly. It is heped that by sampling a wide variety of particle minus that we will be able to derive equations that will be applicable to broad estegarian of crystal types.

Resonated stiess

While the instrument medifications made following \$300-000-5 proved suc-



Pigure 9. 23 January 1984 snow rate plots.

Conclusions

We have compared the fall velocity relationships from SNOW-TWO/Smoke Week IV with those of SNOW-ONE-A and B (Berthel et al, 1983). The equations derived from the 23 January 1984 data generally match those from SHOW-OME-B. The equation coefficients conform with those obtained on 16 January 1984, although the slopes from the 16th's data are generally smaller. The most obvious difference is seen in the coefficients from SNOW-ONE-A's 31 January 1982 storm. These coefficients were approximately forty percent higher. These comparisons may indicate that the particle mix on 23 January 1984 and 12 December 1982 were somewhat similar to 16 January 1964, having slow falling flakes in the large size category. The equation from 31 January 1982 could be explained by the presence of particles of higher densities; however, at this point, that is pure speculation.

The data gathered thus far in the SNOV projects are the baginning of a data base. We feel that the refinements made in both instrument performance and data reduction techniques will enable us to expand this base greatly. It is hoped that by sampling a wide variety of particle mixes that we will be able to derive equations that will be applicable to broad categories of crystal types.

Recommendations

While the instrument modifications made following SHOW-ONE-B proved successful, as demonstrated by the better definition in FVI data, we feel that further changes may be indicated. Studies are currently taking place in the laboratory on the feesibility of using polarized light to enhance our ability to see and measure the smaller particles through better definition. The sampling volume of the FVI has been increased and

IMANUI. CORTETE (8

so dill in authors! that news and page number in Light blue.

greater reduced to the properties



proper focal length adjustments made. This should increase greatly the number of particles available for study. The possibility of digitizing the image is being explored, as well. Although the addition of a retary table to improve collecting efficiency did not receive an indepth test because of very scant ency fall and horizontal wind problems, it does appear to have had some success and plane are being made to mechanise the table for essier use. A snow volume recorder should be completed by the fall of 1984 and in operation for next vinter. Work in being started on the development of an AFGL ASQUE along the lines of those being used currently by CREEL. We hope to have this available in the near future. The data gathered in SHOW TWO/Smoke Work VI still leaves unencueted questions regarding wind effects and occuracy of small samples. Preliminary airflow studies have been conducted but further studies are meceseary before full assessment can be made. It is expected that these studies will be conducted by fall 84. We have defined no fault in the SRM operating in light enow and assume the recorded data to be correct. Purther studies will be performed as comparison data becomes available.

<u>Acknowledgements</u>

A special thanks to Anthony Matthews, Morton Glass, CHEgt Denald HacDonald, Sigt Denais LeGross, and Devid Halita (Ophir) for the on site installation and operation of the equipment. The authors wish to thank Susan Sadofsky and Denald Halesd for their assistance in processing the data. Heny thanks also to Carelyn Padden for typing this paper.

<u>References</u>

Ç

Berthel, R.O. (1962), Snow characterisetion measurements at \$1000-018-4, \$1000-008- A BATA REPORT, U.S. Army C ofpe of Englacete, CHRL Special Report 82-2, 421-437, AFGLED-G2-0003, ANA 118140. Berthel, R.O., Plank, V.G. and Matthews, A.J. (1982), AFGL snow characterization measurements at SHOW-OME-A, Reprints of Snow Symposium II, CRREL, Hanover, RH. Aug 10-12, 33-48, AFGL-TR-83-0121, ADA 128606.

Plank, V.G., Berthel, R.O. and Main, B.
A., (1983): Snow characterization
measurements and R/O correlations obtained during SNONDNE-A and SNOW-OME-B,
SPIE Technical Symposium East 83, Sessjon "Optical Engineering for Cold
Environments", Sub-session "ElectroOptical/Infrared Systems and Effects",
ARGL-TR-83-0214, ADA 132149.

Plank, V.G., Matthews, A.J. and Berthel, R.O., (1983): Instruments used for snow characterisation in support of SNOW-ONEA and SNOW-ONE-B, SPIK Technical Symposium East 83 Proceedings, Session "Optical Engineering for Cold Environments", Sub-session "Optical Hardwere in the Cold." AFGL-TR-83-0213, ADA 132254.

Gibbons, L.C., Matthews, A.J., Berthel, R.O. and Plank, V.G. (1983), Snow characterisation instruments, Instrument Papers No. 316, ARGL-TR-83-0063, ADA 131984.

Berthel, R.O., Plank, V.G., and Main, B.A. (1963), Analysis of Snow Characterisation Data acquired at SNOW-ONE-A and B, Reprints of Snow Symposium III, Chil., Nanover, NN, Aug 9-10, 1983, 43-54, AFEL-TR-63-0222, ADA 132914.

Berthel, R.O., Plank, V.G., and Main, B.A.(1983), SHOW-GHE-A and B charac terisation measurements and data enalysis, AFGL-TR-83-0256, ABA 141245.

being explored, as well. Although the addition of a rotary table to improve collecting efficiency did not receive an indepth test because of very scant snow fall and horizontal wind problems, it does appear to have had some success and plane are being made to mechanise the table for easier use. A snow volume recorder should be completed by the fall of 1984 and in operation for next winter. Work is being started on the development of an AFGL ASCH along the lines of those being used currently by CREEL. We hope to have this available in the near future. The data gathered in SNOW TWD/Smoke Week VI still leaves unanswered questions regarding wind effects and accuracy of small samples. Preliminary airflow studies have been conducted but further studies are necessary before full assessment can be made. It is expected that these studies will be conducted by fall 84. We have defined no fault in the SRM operating in light snow and assume the recorded data to be correct. Purther studies will be performed as comparison data becomes available.

Acknowledgements

A special thanks to Anthony Matthews, Morton Glass, CMSgt Donald MacDonald, SSgt Dennie LeGross, and David Melita (Ophir) for the on site installation and operation of the equipment. The authors wish to thank Susan Sadofsky and Donald McLeod for their assistance in processing the data. Heny thanks also to Carolyn Fadden for typing this paper.

References

Berthel, R.O. (1982), Snow characterisetion measurements at SHOW-ONE-A, SHOW-ONE- A DATA REPORT, U.S. Army C orps of Engineers, Chril Special Report 82-2, 421-437, AFGLTR-82-0003, ADA 118140.

Berthel, R.O., Plank, V.G. and Main, B.A. (1963), AFGL annu characterization measurements at SHOW-OME-B: preliminary report, SHOW-OME-B DATA REPORT, U.S. Army Corps of Engineers, Christ Special report 63-16, 197-208, AFGL-TR-63-0174, ABA 130556.

ANA 128606. 35-48, AFGL-TR-83-0121,

Plank, V.G., Berthel, R.O. and Main, B. A., (1983): Snow characterisation measurements and E/O correlations obtained during SNOWDHE-A and SNOW-OHE-B, SPIE Technical Symposium East 83, Section "Optical Engineering for Cold Environments", Sub-session "Electro-Optical/Infrared Systems and Effects", AFGL-TR-83-0214, ADA 132149.

Plank, V.G., Matthews, A.J. and Berthel, R.O., (1983): Instruments used for snow characterisation in support of SHOW-ONEA and SHOW-ONE-B, SPIE Technical Symposium East 83 Proceedings, Session "Optical Engineering for Cold Environments", Sub-session "Optical Hardware in the Cold." AFGL-TR-83-0213, ADA 132254.

Gibbons, L.C., Matthews, A.J., Berthel, R.O. and Plank, V.G. (1983), Snow characterization instruments, Instrument Papers No. 316, AFGL-TR-83-0063, ADA 131984.

Berthel, R.O., Plank, V.G., and Main, B.A. (1983), Analysis of Snow Cheracterization Data acquired at SNOW-ONE-A and B, Reprints of Snow Symposium III, CREE, Hanover, NV, Aug 9-10, 1983, 43-54, ARGL-TR-83-0222, ADA 132914.

Berthel, R.O., Plank, V.G., and Main, B.A.(1983), SHOW-ONE-A and B charac terination measurements and data analysis, AFGL-TR-83-0256, ADA 141245.

Which Werer . | M

o posta mither of the topics of or employing the filt felting

